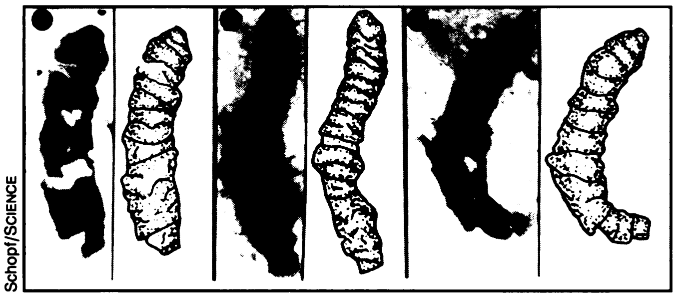
Fossils Show Early Diversity of Life

The record of ancient life preserved in Earth's oldest rocks shrinks to a handful of tattered pages as paleontologists struggle back through time to the Archean era — the first 2 billion years of our planet's history. Now, recently identified fossil microorganisms add a potentially important chapter to that incomplete record. These fossils suggest that a diverse range of cyanobacteria — creatures that use light as an energy source and produce oxygen — may have thrived about 1 billion years after Earth formed.


Schopf/SCIENCE

Images and matching interpretive drawings of three individual microorganisms from a collection of 3.5-billion-year-old fossils discovered in western Australia.

Paleobiologist J. William Schopf of the University of California, Los Angeles, has identified 11 distinct species of cyanobacteria-like creatures preserved in 3.465-billion-year-old rock deposits in western Australia. The microscopic creatures, embedded in some sort of sticky substance, probably lived in shallow water, says Schopf. They grew into filaments of connected cells, resembling the cyanobacteria discovered previously in 2.1-billion-year-old Canadian rocks, Schopf reports in the April 30 SCIENCE.

The microorganisms vary significantly in the shapes of their individual cells and in their overall lengths and thicknesses. This diversity demonstrates that primitive life had already seen great evolutionary change by an early point in Earth's history, says Schopf.

Considering the odds against the preservation of such ancient fossils, Schopf comments, "I feel just enormously pleased that we've finally got something that's nearly 3.5 billion years old, that's diverse and interesting and well-preserved enough to interpret." Over time, heat and pressure can all but obliterate traces of ancient life from the geological record.

But are Schopf's fossils truly the ancestors of oxygen-making cyanobacteria? Currently, the identity of these somewhat poorly preserved microorganisms remains subject to interpretation. "I personally think it will turn out that these are cyanobacteria, but it's very difficult to nail that at the moment," says Schopf.

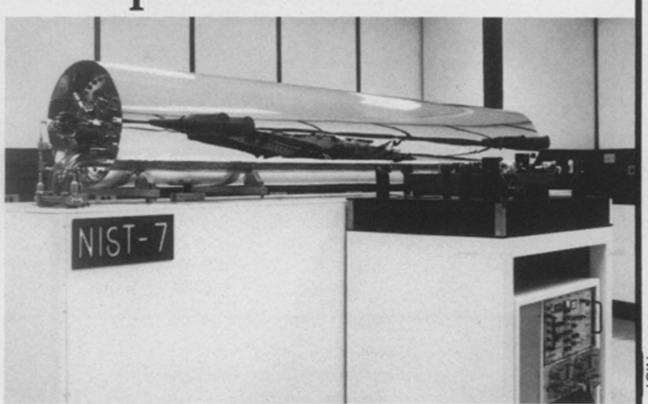
The true identity of the creatures in Schopf's fossil menagerie may bear on a controversial question: When did Earth's atmosphere begin to build up significant concentrations of oxygen? Proof of a thriving population of oxygen-generating cyanobacteria 3.5 billion years ago, Schopf maintains, "would show that the current ecological system, with oxygen production and utilization . . . may well have been established at a remote time in Earth's history."

Scientists who accept the conventional wisdom on the "rise of oxygen" might disagree with Schopf. Until about 2.2 billion years ago, according to the standard account, dissolved iron in the oceans combined with any free oxygen in the environment. Thus, aerobic (oxygen-using) creatures — phytoplankton, for instance — could not have existed in the Archean era described in textbooks.

In contrast to this standard view, accumulating evidence indicates that oxygen-producing microbes evolved early in the Archean era and began to enrich the oceans with oxygen, argues Kenneth M. Towe, a paleobiologist at the Smithsonian Institution in Washington, D.C. Towe's research suggests that the amount of iron present in the Archean oceans could not have soaked up all the available oxygen (SN: 12/1/90, p.347). Without aerobic organisms around, atmospheric oxygen would surely have built up earlier than many believe, he says.

The mystery of when Earth's oxygen levels rose is so complex that proving cyanobacteria existed 3.5 billion years ago will not in itself settle the issue, says paleontologist Andrew H. Knoll of Harvard University. "Dealing with almost anything in the first half of Earth's history is not simple, because the rock record stinks," he explains. However, "some glorious insights have been generated, and I think that just the ability to say life was present 3.5 billion years ago is really great." — *D. Pendick*

Starting up an improved atomic clock



NIST

It doesn't look at all like the trusty digital alarm clock you may have at your bedside, but it certainly keeps better time. Placed into operation on April 22 by the National Institute of Standards and Technology (NIST) in Boulder, Colo., this new atomic clock will neither gain nor lose a second in the next 1 million years. Designated NIST-7, it replaces NBS-6, the atomic clock started up in 1975 to serve as the U.S. contribution to setting and maintaining the international standard for time and frequency.

The clock's glistening, cylindrical facade, about 2.2 meters long, hides several layers of magnetic shielding. Within this cocoon, a small oven at one end gently heats up cesium metal to release cesium atoms, which are collimated into a narrow beam only 1 millimeter wide. As the cesium beam passes down the center of a long, evacuated tube, laser light excites the individual atoms to ensure that they all end up in the same electronic state.

These atoms then enter a 1.55-meter-long chamber in which microwaves reflect back and forth. The frequency of these microwaves — 9,192,631,770 hertz — corresponds precisely to the energy needed to excite a cesium atom from its initial electronic state to a state of slightly higher energy. Bathed by another laser, the microwave-excited atoms then fluoresce, giving off electromagnetic radiation. Electronic circuitry locks the microwave signal to this atomic signal, so the system maintains a constant frequency. One second is represented by 9,192,631,770 of these vibrations.

"It's actually a fairly simple procedure," says NIST's John P. Lowe. But it took years of effort to refine the technique and build a better clock.

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